

1994  
Executive Research Project  
F12

# Watervliet Arsenal: Snapshot of Industrial Base Future

*Lieutenant Colonel*  
**Gregory F. Potts**  
*United States Army*

*Faculty Research Advisor*  
Lieutenant Colonel Marcus R. Erlandson, USA



19941201 012

The Industrial College of the Armed Forces  
National Defense University  
Fort McNair, Washington, D.C. 20319-6000

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

## REPORT DOCUMENTATION PAGE

|  |  |   |             |          |                         |
|--|--|---|-------------|----------|-------------------------|
| 1a. REPORT SECURITY CLASSIFICATION<br>Unclassified                               |  | 1b. RESTRICTIVE MARKINGS  |             |          |                         |
| 2a. SECURITY CLASSIFICATION AUTHORITY<br>N/A                                     |  | 3. DISTRIBUTION/AVAILABILITY OF REPORT<br>Distribution Statement A: Approved for public release; distribution is unlimited. |             |          |                         |
| 2b. DECLASSIFICATION/DOWNGRADING SCHEDULE<br>N/A                                 |  | 5. MONITORING ORGANIZATION REPORT NUMBER(S)<br>Same   |             |          |                         |
| 4. PERFORMING ORGANIZATION REPORT NUMBER(S)<br>NDU-ICAF-94-F12                   |  | 7a. NAME OF MONITORING ORGANIZATION<br>National Defense University  |             |          |                         |
| 6a. NAME OF PERFORMING ORGANIZATION<br>Industrial College of the<br>Armed Forces | 6b. OFFICE SYMBOL<br>(If applicable)<br>ICAF-FAP | 7b. ADDRESS (City, State, and ZIP Code)<br>Fort Lesley J. McNair<br>Washington, D.C. 20319-6000                             |             |          |                         |
| 8a. NAME OF FUNDING/SPONSORING<br>ORGANIZATION                                   | 8b. OFFICE SYMBOL<br>(If applicable)             | 9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER   |             |          |                         |
| 8c. ADDRESS (City, State, and ZIP Code)  |  | 10. SOURCE OF FUNDING NUMBERS   |             |          |                         |
|  |  | PROGRAM ELEMENT NO.   | PROJECT NO. | TASK NO. | WORK UNIT ACCESSION NO. |

11. TITLE (Include Security Classification)

Waterloo Arsenal: Snapshot of Industrial Base Future

12. PERSONAL AUTHOR(S)

Gregory J. Potts

13a. TYPE OF REPORT  
Research13b. TIME COVERED  
FROM Aug 93 TO Apr 9414. DATE OF REPORT (Year, Month, Day)  
April 1994

15. PAGE COUNT 48

16. SUPPLEMENTARY NOTATION

|                  |   |           |  |
|------------------|---|-----------|--|
| 17. COSATI CODES | 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) |           |  |
| FIELD            | GROUP   | SUB-GROUP |  |
|                  |   |           |  |
|                  |   |           |  |

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

SEE ATTACHED



|  |  |
|--|--|
| 20. DISTRIBUTION/AVAILABILITY OF ABSTRACT<br><input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS | 21. ABSTRACT SECURITY CLASSIFICATION<br>Unclassified |
| 22a. NAME OF RESPONSIBLE INDIVIDUAL<br>Judy Clark  | 22b. TELEPHONE (Include Area Code)<br>(202) 475-1889 |
| 22c. OFFICE SYMBOL<br>ICAF-FAP   |  |

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted.  
All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

## **ABSTRACT**

### **Watervliet Arsenal: Snapshot of Industrial Base Future, LTC Gregory F. Potts**

In this document, LTC Potts discusses the history of Watervliet Arsenal, the current conditions surrounding it, and recommends where it might position itself for the future.

## DISCLAIMER

This research report represents the views of the author and does not necessarily reflect the official opinion of the Industrial College of the Armed Forces, the National Defense University, or the Department of Defense.

This document is the property of the United States Government and is not to be reproduced in whole or in part for distribution outside the federal executive branch without permission of the Director of Research and Publications, Industrial College of the Armed Forces, Fort Lesley J. McNair, Washington, D.C. 20319-6000.

|                    |                                     |
|--------------------|-------------------------------------|
| Accession For      |                                     |
| NTIS GRAAI         | <input checked="" type="checkbox"/> |
| DTIC TAB           | <input type="checkbox"/>            |
| Unannounced        | <input type="checkbox"/>            |
| Justification      |                                     |
| By                 |                                     |
| Distribution/Avail |                                     |
| Availability Codes |                                     |
| Distr              | Avail and/or<br>Special             |
| A-1                |                                     |

## TABLE OF CONTENTS

| <b>Subject</b>  | <b>Page</b> |
|---|-------------|
| Introduction  | 1           |
| Historical Context  | 3           |
| Ceramics Are Not Composites;<br>Composites Are Not Ceramics | 6           |
| The Opportunities For The Future                            | 9           |
| Environment: Evolving, But Unified<br>Government Front      | 11          |
| Environment: Congressional Legislation                      | 15          |
| Environment: AMC Acts                                       | 18          |
| Applications Of Ceramics and Composites                     | 20          |
| International Cooperation                                   | 22          |
| Electro-Magnetic Guns                                       | 24          |
| Conclusions   | 27          |
| Recommendations   | 32          |
| Endnotes  | 35          |

## WATERVLIET ARSENAL

### Snapshot of Industrial Base Future

#### **INTRODUCTION**

This paper's genesis occurred with the autumn 1992 Watervliet Arsenal (WVA) request and statement of work for a prospective faculty or student research effort to the Industrial College of the Armed Forces (ICAF). Simply stated, the task was to define WVA's operational environment, describe primary market trends, and to provide a strategic forecast for inclusion into WVA's evolving strategic plan. The product of this effort was the 1992 Executive Research Project G3, " Watervliet Arsenal: Snapshot of Industrial Base Change " by LTCs Robert Dees and Bristol Williams.<sup>1</sup> Upon its completion, it formed a key portion of the WVA Strategic Enterprise Plan, the current road map for Watervliet's near and midterm operational plan.<sup>2</sup> Having seen the benefit which might be derived from ICAF students researching its particular requirements, WVA submitted another scope of work and list of requirements to ICAF on 5 January 1993. This request, building upon the work of Dees and Williams, and the in-being WVA Strategic Enterprise Plan, requested work both in the area of ceramics and composites applied technologies overlaid on WVA's historical and widely recognized core competencies in large pressure vessel manufacturing, i.e., large caliber, thick-walled cannon. This project appeared in the AY 1993-94 ICAF Research and Writing Handbook as #F12, " Strategic Planning Support

to Watervliet Arsenal", <sup>3</sup> and upon evaluation by the Faculty Research Advisor, LTC Marcus R. Erlandson, the author was accepted as the researcher for the project in September 1993. At a subsequent In-process Review (IPR) at WVA on 1 October 1993 between the author and the WVA Director of Advanced Technology and Systems, Mr. David Callahan, the scope was narrowed and solidified to become:

- (1) Future of ceramics and composites applications for cannon
- (2) In light of cannon capacity and capability, what types of related items could WVA manufacture for the Department of Defense (DOD) <sup>4</sup>

Although these are the primary questions addressed throughout, WVA's future as part of the American and DOD Industrial Bases will be the broader question also discussed.

## HISTORICAL CONTEXT: WATERVLIET ARSENAL, WHERE IT HAS BEEN

Watervliet Arsenal is home to a long, productive history of service to the military and the nation in forging the armaments of war since The War of 1812. In the autumn of 1812, the Chief of Ordnance, Colonel Decius Wadsworth, wrote that "The principal establishment for making fixed ammunition and all the small articles of equipment for a train of artillery will be at Albany [ Watervliet ]...". The War Department approved; twelve acres of land were purchased from a local farm couple, and by 1817, people began to speak of the "Arsenal at Watervliet ( Dutch for "floodtide"), N.Y.". The fact that the Arsenal was located on expanding railways, and at the intersection of canals and riverways greatly influenced its growth up through the Civil War. Its involvement during the 1860's was robust in that a wide variety of items were manufactured there to include ammo boxes, small arms parts, ammunition, and artillery carriages and limbers.<sup>5</sup>

Just as the country changed so substantially during and after the Civil War, so was to be the life of Watervliet. On May 3, 1883, Congress approved an Act which would not only change WVA in the 19th Century, but would also hold similar portent 100 years later. The Act "...authorized and requested...from the Army and Navy six officers who shall constitute a board for the purpose of examining and reporting to Congress, which of the navy yards, or arsenals owned by the government has the best location and is best adapted for the establishment of a government foundry..., for the manufacture of heavy ordnance {large caliber guns} adapted for modern warfare, for the use of the Army and Navy of the United States...".

Even though there are many more sidelights to this issue, Watervliet Arsenal was chosen as **THE** facility for a variety of reasons:

- (1) Lower costs to transfer in capital equipment and upgrade existing plant
- (2) Lower cost of living in the WVA area
- (3) Lower labor costs in the WVA area
- (4) Availability of skilled workers in the area and willingness of other workers to re-locate there
- (5) Size and condition of existing plant for expansion/changing requirements
- (6) Good surface and sub-surface geology if facility expansion were needed
- (7) Being so far inland, WVA was "absolutely safe from hostile fleets and vessels"
- (8) Transportation, especially rail and waterway connections, was better than the other sites, by far.<sup>6</sup>

WVA continued to excel through the World Wars, the Korean War, and the conflict in Southeast Asia as the nation's premier large gun producer. This capability continues to the present day, in great part, because several hundred million dollars in sophisticated manufacturing equipment and ancillary infrastructure were purchased by the Army Materiel Command in the 1970's and 1980's under a program entitled REARM---Renovation of Armament Manufacturing.

## **HISTORICAL CONTEXT: WATERVLIET ARSENAL, WHAT IT IS TODAY**

Watervliet Arsenal is a government-owned, government-operated (GOGO) industrial plant which produces thin and thick-walled cannon---the only facility of its kind in the U.S. There does exist some capability in the Navy's Louisville Site of Crane Division of the Naval Sea Systems Command,

and also some capability in the Naval Guns Division of the United Defense Corporation (formerly FMC) in Minneapolis.<sup>7</sup>

In addition to the REARM investment mentioned earlier, WVA has done more to help itself to maintain its technological sophistication. WVA has received a \$31 million Federal government grant to develop a Computer Integrated Manufacturing (CIM) capability for the Arsenal. This automated machine tool capability has already allowed WVA to reap financial and reputation benefits as a flexible (FCIM) manufacturer of spare and machined parts.<sup>8</sup> The future of FCIM lies not so much in what WVA can do for itself, but rather in what WVA can do and is doing for its customers.

## **CERAMICS ARE NOT COMPOSITES; COMPOSITES ARE NOT CERAMICS**

Before discussing the various options available for WVA in the future, a short discussion of ceramics and composites is necessary. A common but erroneous misconception is that these terms are synonymous; they are not.

### **Ceramics**

Ceramics are compounds of metallic and nonmetallic elements. Known for more than 6,000 years, ceramics refers to both the basic material and the end product itself. Derived from the Greek roots, *keramos*, meaning potter's clay and *keramikos* meaning clay products, ceramics have become popular because of their high hardness and compressive strength, high temperature resistance, and chemical inertness. These characteristics have made them very attractive for such technological applications as heat-engine components, cutting tools, and components requiring heat and corrosion resistance. Perhaps the most common industrial application has been that of automotive spark plugs. More recently, automotive components such as exhaust-port liners, coated pistons, and cylinder liners have used ceramics. It is key to note that in each of these products, the ability to perform at high operating temperatures, while resisting corrosion and maintaining product strength, makes ceramics the preferred material.

There are actually two general categories of ceramics: *traditional* (pottery) and *industrial*, also known as engineering, high-tech, or fine. The structure of ceramic crystals is very complex and derives its strength from its ionic and covalent bonding, properties which make them stronger than

metals, particularly in hardness, and thermal and electrical resistance. Add to this the fine, granular structure of the basic material, kaolin clay, and this characteristic becomes more pronounced. Other common basic materials for ceramics are silicas, nitrides, carbides, and aluminas, each displaying a particular set of characteristics based upon purity and combination with other materials. The carbide family shows particularly high promise in thermal and pressure barrier applications. Programs are underway to improve the strength, toughness, fatigue, and resistance to corrosion, wear, and thermal shock, as well as purity, and reproducibility of application.<sup>9</sup>

## **Composites**

Whereas ceramics are combinations of metallic and nonmetallic elements, composites are combinations of two or more chemically distinct and insoluble phases or materials whose properties are superior to those of the phases acting independently. These properties are improved by embedding reinforcements of various types such as glass or graphite fibers. Common applications are found throughout boats, automobiles, and sporting goods, and households, such as Formica countertops. Perhaps the most common application is fiberglass.

This is not to suggest that composites is a new technology. The oldest recorded examples of the technology being applied go back 6,000 years when straw was added to bricks and mud huts for structural strengthening. More recently, the reinforcing of concrete with metal rods has become a common application. Multiple fibers can be used to create hybrid composites, but regardless, the product will always consist of a matrix of a continuous phase item injected or inlaid with a dispersed or discontinuous phase, the fibers

themselves. These reinforced materials usually have high specific strength, improved fatigue resistance, and greater toughness while generally weighing less than comparable metallic structures, such as the kevlar military helmet. Great weight savings are achieved while not sacrificing strength characteristics. In addition to the sporting goods mentioned earlier, aircraft and spacecraft ( such as the B-2 and the Voyager ) have been shown to have ideal applications for composites. <sup>10</sup>

## THE OPPORTUNITIES FOR THE FUTURE

Is what LTC Dees and LTC Williams concluded in 1992 still valid today ? That is, that the importance of ceramics and composites in thick-walled, large caliber gun tubes would be important for WVA's future ? It appears that there are five general avenues of approach available to WVA in the future:

- (1) Incremental advances and expansion of current technology and processes
- (2) Maintenance of current technology and expansion of Security Assistance
- (3) Growth as a Center of Civil-Military Technological Excellence
- (4) Technological Advances, such as Electro-magnetic Guns
- (5) Establishment as The Replenishment( Mobilization ) Base for Cannon Production

The need for WVA's involvement in large caliber, thick-walled guns is enhanced by the common belief that it possesses a "unique national and defense capability within our industrial base which must be preserved".<sup>11</sup> This remains a widely-held belief both in DOD and throughout the Federal government. Such public and high-level accolades, though, should not be allowed to go to anyone's head; there are compelling realities which WVA and others must be faced with.

Watervliet Arsenal finds itself at the intersection of a number of major trends affecting readiness, mobilization, technology, and the Federal Budget:

- (1) The unquestioned primacy of readiness of military forces as DOD's #1 priority, and WVA's role as the sole maker of gun tubes in North America to support other priorities, such as sustainment and modernization, as the forces decrease in size;

- (2)** The oft-stated need to guarantee WVA's core capability as the cannon maker for surge and contingency purposes when economies of scale to produce those guns during production lulls are not present;
- (3)** The reality that the U.S. is on the verge of a number of leap-ahead technologies in both the military and civilian spheres, and that for either sector to afford such technologies, new partnerships will have to be formed;
- (4)** The fact that the above three will occur in Federal Budgetary times in which fewer dollars will be available and smarter choices will have to be made; and,
- 5)** The Nature of the Threat for which WVA demonstrated its capability for the past 40 plus years has changed in that the Cold War is over, and the Soviet Union is no more.

As is apparent from the points above, the trends are not in consonance with each other, and, in fact, conflict. But there are, in fact, some clear trends for today and tomorrow which do emerge.

## ENVIRONMENT: EVOLVING, BUT UNIFIED GOVERNMENT FRONT

Few foresaw the downfall of the Soviet Union, the dissolution of the Warsaw Pact, and the physical crumbling of the Berlin Wall until it was announced in the common press. These events, beginning in the autumn of 1989 with the "Fall of the Wall", actually followed an already decreasing U.S. Defense Budget. As noted in Mr. David Berteau's Report of the Defense Conversion Commission of December, 1992,

Outlays are planned to decline from \$340B in 1987 to \$237B in 1997, a reduction of about 30%. Outlays totalled \$306B in 1992. The planned reduction in outlays from 1987 to 1997 is therefore about 33% complete by 1992. <sup>13</sup>

The key point to note here is that implicit in a 33% figure is that there is still much yet to be completed.

The Defense Conversion Commission also spoke of the Congressionally-mandated Base Realignment and Closure Commission ( BRAC ) which would facilitate conversion by " reducing or eliminating those defense facilities, particularly in the industrial base, which may be excess to current or future needs." <sup>12</sup>

These reductions from the BRAC were not to come at the expense of the reality of the changing Threat. Paragraphs in the October 1993 Report of the Bottom-Up Review speak of a FSU ( Former Soviet Union ) Defense Military Partnership. One of the three components of this partnership is *Expanded defense and military contacts* which include "moving beyond a series of single contacts to programs which foster ongoing

relationships".....[to] " provide concrete technical assistance." The Review also recommended or mandated such programs as:

Integrating major parts of the defense industrial base with the commercial industrial base and having DOD adopt the best practices of today's commercial industries...

We can no longer rely on a large industrial base consisting of companies who cater only to the needs of the military....<sup>13</sup>

The Report on the Bottom-Up Review further recommended that the U.S. maintain " leading edge technology " by looking beyond our traditional base and by concurrently broadening the DOD industrial base. It further stated that this could lead to the integration of military and commercial advance technologies which may have " dual-use " spin-off potential throughout both the government and commercial sectors---thus helping both in the process. <sup>14</sup>

In June 1992, the Congressional Office of Technology Assessment (OTA) recommended that:

Congress provide funds to study the base, the adaption (sic) of manufacturing innovations and maintenance of critical manufacturing skills. Funding would be necessary for long range planning, stockpiling and the maintenance of excess peacetime production capacity in select areas to meet potential surge and mobilization requirements. <sup>15</sup>

In his January, 1993 Annual Report to the President and Congress Secretary of Defense Dick Cheney supported this thrust:

If future restoration of a critical, unique capability--or restart of an idled capability--would be prohibitively costly, then some action must be taken within the FYDP ( Future Year Defense Plan ) to preserve key elements of that production process. ... The question of whether or not specific industrial capabilities will be available at some point beyond the six-year window of

the FYDP is a key issue. Program terminations may result in closure of key facilities or loss of special skills, processes, and technologies.<sup>16</sup>

And furthermore, in the recently-published Defense Planning Guidance (DPG) 1995-1999, then-Secretary of Defense Les Aspin said in part to "Program for industrial preparedness measures to permit accelerated production of only those munitions, critical troop support items and spares where this is a cost-effective alternative to full war reserve inventories."<sup>17</sup>

So, there appears to be consensus within the government on the future of the Industrial Base that it will be radically different and smaller from the past, but capable of responding to critical national contingencies. What about voices from the other component, the commercial sphere? Numerous government contractors as diverse as TRW, Texas Instruments, Martin-Marietta, and Loral Federal Systems have all spoken, and already acted upon a downsizing/rightsizing of their defense activities to meet the probable future of Defense.

Perhaps the most relevant among all speakers, though, whether commercial or government, is the new Secretary of Defense, Dr. William J. Perry. In recent statements, Dr. Perry sees massive reductions in available Defense budgets continuing into the near future as a result of "The New Era" in which America is currently operating. As the Defense Drawdown is accomplished, both hollow forces and hollow industry must be avoided. To maintain fully ready forces, the Industrial Base must be kept vibrant in light of the drawdown. A Defense Industrial Base, shrunk to a third of its size in just the last decade, can be kept vibrant with an eye towards emphasizing low-rate production. He said this Base will not be a government-only

proposition; much of it will remain in the civilian sector. A more comprehensive integration of the Defense Industrial Base into a National Industrial Base will be inevitable. Dr. Perry concluded that there will continue to be support for government-owned and/or government-operated facilities in those specific core competencies for which there may be little commercial utility or business interest.<sup>18</sup> WVA may well fall into this category. However, a greater realization that the Industrial Base is composed of products, processes, and technologies which are vital to the nation's health, and have both military and commercial application, is arising. The implication for WVA is that it must be the best source for a wider or more vital array of products, processes, and technologies germane only to the military, and in which commercial producers do not necessarily care to participate.

## ENVIRONMENT: CONGRESSIONAL LEGISLATION

There is considerable federal government and industry support in place for the industrial base in general, but certainly not in the ways to which we have become accustomed. In his January 1994 Annual Report to the President and Congress, then Secretary of Defense Les Aspin stated in regard to the Industrial Base that:

The Department will rely on market forces to the maximum extent practicable to guide the consolidation of the defense industrial base. Recognizing the inevitability of smaller markets and heavier competition, many defense contractors have taken their own steps to adjust--- by diversifying into non-defense markets, merging with or purchasing other firms, or shrinking to match the smaller market. These steps represent the normal response of market forces to declining demand. They will produce a smaller, but still viable defense industry. <sup>19</sup>

The handwriting is clearly on the wall. Partnerships must be pervasive, technologies need to have dual-use commercial and military applications. Researching technologies will often be so expensive as to require cooperation among all parties to bring them to successful completion, and hard choices will have to be made among the whole panoply of competing defense product needs to determine which can be produced in-house, contracted out, allowed a "warm" base, and limited to research.

So how does this play in the case of WVA ? In sum, it appears that there has been much activity and legislation on WVA's behalf. However, what also appears most evident is that there little substance to support this

activity and legislation. WVA has, in the recent past, survived on the work provided it from the U.S. tank manufacturing facilities at Detroit and Lima, and the re-build facility at Anniston Army Depot ( ANAD ), Alabama. WVA will have to look elsewhere if such work or level of work is to be maintained.

The 1986 Technology Transfer Act provides numerous opportunities for government laboratories and manufacturing operations to share facilities, resources and personnel, with the ensuing benefits, with civilian schools firms and even governments.<sup>20</sup> ( This can be particularly helpful for WVA when the immediate presence of Benet Labs is factored in. ) This arrangement, commonly known as a CRDA---Cooperative Research and Development Agreement---has provided great impetus to increased cooperation between government facilities and private firms.<sup>21</sup> A little realized, but irksome, provision of this law which restricted intellectual property rights such as patents has since been ameliorated on WVA's behalf with subsequent legislation such as the Stratton Act and the McNulty Amendment.<sup>22</sup> These last two pieces of Congressional legislation, named after the former and now current Congressman, of the district WVA in which is located, were designed specifically for WVA to ensure its pre-eminence in cannon manufacturing while providing it the maximum latitude to pursue commercial ventures under the CRDAs. Further specific language inserted by Congressman McNulty in the FY94 Defense Authorization Bill streamlined the provisions of the 1986 Technology Transfer Act even more so on WVA's behalf to allow them to optimize any and all preferred non-defense-related ventures.

All this assistance does stand as an indicator of support at the national level for WVA's future both in its core capability, and in its non-

traditional/non-defense future. However, as alluded to earlier, and as exciting as the prospects of all this civil-military cooperation sounds, it has so far borne little fruit. Rather than a broad national consensus for WVA's future, this legislative package is support from specific Congressmen and districts. Dual-Use and Defense Conversion are popular terms, and ones in which the Administration has invited all to participate. The major drawback to this bearing fruit is that we have few customers chasing many suppliers. Furthermore, defense industries will benefit from these initiatives at varying levels of success. WVA's prospects to significantly improve their position in this arena are dim.

## ENVIRONMENT: AMC ACTS

AMC, the Army Materiel Command, is WVA's parent activity. Sandwiched in between these two organizations is the Rock Island, Illinois-based Armament, Munitions, and Chemical Command, AMCCOM. As part of an ongoing restructuring, and partly as a result of the BRAC, AMCCOM is in the process of merging with the DESCOM---Depot Systems Command---of AMC. This will place all of the Army's manufacturing facilities---AMCCOM's ammunition plants and arsenals, and DESCOM's depots---under one head. The former Commanding General of this new unit, called the Industrial Operations Command---IOC---MG Paul Greenberg ( who retired from active military duty on 1 February 1994 ), sees great opportunities for economies of scale. Lessening of the sometimes artificial distinction between a manufacturing arsenal and a re-manufacturing depot, and a closer relationship between the R & D labs and any production facility would help achieve this. This is a position being increasingly advocated by OSD as inherently more efficient from a continuity and reduction of overhead basis, two strong points in any defense discussion today. Activity-Based Costing ( ABC ), an overhead allocation basis in which costs are distributed across activities rather than to individual product lines, has been adopted by the Defense Logistics Agency ( DLA ). Such a basis could do much to make the WVAs of the world appear more competitive. As much as he sees the optimization of the IOC facilities, he also sees their roles as being tightly interwoven with the commercial industrial base. Rather than being solely an advocate for the government side, he has seen the benefit of having a strong commercial base in those areas where they possess the greater expertise. <sup>23</sup>

The commercial munitions base stands as an excellent example of this. Companies have already facilitated for the economical production of certain types of ammunition and their components. There are sterling examples of which types of the civilian industrial base should be maintained. Whether Loral-Vought's MLRS facility at Camden Arkansas, or Alliant Techsystems in suburban Minneapolis, these are vital parts of that base which need to be kept and maintained.

Rather than seeing *bases* or *facilities* for certain *products* as either being cold or hot, MG (RET) Greenberg advocates a different approach. He holds an optimal and rationalist position in which *some products* may not need any skills or capital equipment retention or layaway at all, whereas *some products* may need to be maintained at a cool surge or mobilization rate just to ensure the line can go hot, if need be. Not lost in this argument is the question of WVA's role as a vital part of the nation's Industrial Base. Aside from being the premier cannon maker on earth, WVA also possesses what may be the finest machine shop on earth.<sup>24</sup> The addition of the REARM and FCIM equipment mentioned previously was put to great use during the Operations Desert Shield and Storm. The "no-notice" design and production of the air-dropped "bunker-buster" munition allowed WVA to showcase its talents in this area.

Dr. Perry's vision, Mr. Aspin's writings, MG (RET) Greenberg's field experience, and WVA's experience and capability as a true National Resource dovetail nicely into what may be the future of WVA in the new National Industrial Base.

## APPLICATIONS OF CERAMICS AND COMPOSITES

From the quick overview of ceramics and composites, it may be apparent, that for thick-walled large caliber guns, ceramics would be the product of choice for future applications. Its high resistance to thermal pressure makes it a natural if correctly developed. The application of that technology, however, is more complex.

The primary reason for using ceramics and composites would be to meet a military requirement for enhanced wear life of gun tubes while reducing their weight, allowing for more advanced/hotter propellants to be fired and at no increased cost. Both government and civilian laboratories are making strides in these areas.

Benet Laboratories, an Army R & D facility collocated with WVA, is testing some promising ceramic applications. Using a technology also researched by the Batelle Laboratories, Dr. George Capsimanlis of Benet is investigating "sputtering" for cannon tubes.<sup>25</sup> This process provides a wafer-thin uniform ceramic coating, such as tantalum boride, continuously along the inside of the tube. Although not yet test-fired, this technique theoretically suggests that much hotter, more volatile propellants can be shot with even less wear on the tube. Other work done by Benet scientists mathematically proves that the structure of the tube can be maintained with the ceramic coatings while actually reducing the weight and volume of metal used in the tube itself.<sup>26</sup> This technique could also have significant positive impact from an environmental standpoint in that this could replace the chromium linings currently being used. Disposal of chromium oxide during the production process creates an environmental problem WVA would prefer

to avoid. Overall, this process may appear rather promising technologically, despite the fact that cost figures for such an application are not yet devised. From an Army-in-the-field perspective, though, these applications are not particularly attractive. Extended barrel life for tank main guns is not a priority in that barrel tube life currently tends to outlast the other tank subsystems between rebuilds. In short, there is no Army requirement for enhancing the current main gun tube.

The Armament Research, Development and Engineering Center ( ARDEC ) at Picatinny Arsenal, New Jersey is working closely with the University of Texas at Austin to develop Advanced Composite Barrels ( ACB ) capable of firing propellants as hot as 20,000 degrees ( Kelvin ).<sup>27</sup> Using a variety of metal, ceramic, and composite cylinders wrapped among a hydraulic pressure medium, this specific technology shows promise for application and production, but well into the future.

## INTERNATIONAL COOPERATION

An area of future growth and development which is not often heard is actually a convoluted outgrowth of diplomatic initiatives taken since the dissolution of the Warsaw Pact. In a program known as " Partnership for Peace " former Pact countries can apply for "associate " membership in NATO. Although not allowing these new members the full rights and responsibilities of membership in NATO, this is seen as a preliminary step towards such complete status. Romania was the first country to be accepted into NATO under this new program, while several others are in the process of gaining admission.

A interesting facet of this " associate " membership is the expectation that they will participate in joint ( combined ) training exercises with other NATO members. A primary thrust of any such exercise or interoperability is similarity or compatibility of equipment, without which the interoperability and subsequent value of the training are limited at best. As the creator and chief advocate of this program, the United States is in an enviable position to promote and ensure the compatibility of this equipment. This is where WVA may have a role.

Discussions with the Deputy of the U.S. Army's Security Affairs Command ( USASAC ) indicate that there is interest in pursuing the upgrade of major pieces of ground equipment of the former Warsaw Pact countries.<sup>28</sup> Lawyers with the USASAC's parent command, AMC, reveal that there is no statute prohibiting the re-manufacture or upgrade of the equipment. WVA's current technology in barrels for main tank guns is recognized as the best in the world, and is yet, a mature technology. Tank main gun barrel tube life

routinely exceeds a thousand rounds and often meets a 1,500 round life. Therefore, upgrading the potentially more than 100,000 main tank guns of the FSU and its former Warsaw Pact allies, and providing a sufficient, but non-quantifiable, number of replacement spares would cause at least four benefits:

- (1) Standardization of major ground combat equipment among future allies, thus aiding interoperability, training, and support
- (2) Further protection of a vital portion of the US industrial base.
- (3) Preservation, and probably expansion, of a significant number of quality jobs for WVA.
- (4) Promulgation of current US mature technology.

While not a very glamorous option, it takes full advantage of capital equipment already invested at home, and capitalizes on core capability. The Czech Republic has already approached several Western nations in hopes of upgrading its T-72 fleet with mature technology enhancements. Other companies, such as Royal Ordnance of Great Britain, are already involved in upgrades of certain nations' tanks to a NATO 105mm standard. WVA, through USASAC, could do well by competing on the early edge of these programs.

## ELECTRO-MAGNETIC GUNS

Electro-magnetic guns ( EMG ) comprise a new era of technology much unlike any currently-fielded guns. EMG are unique in that they

- (1) Use large pulses of electrical energy to propel projectiles
- (2) Achieve increased velocities, ranges, and energy on target
- (3) Use energy directly derived from the vehicle's fuel supply

Why would a military wish to exploit such a technology ? Although in the early stages of testing, there are four probable payoffs for investing and promulgating such a gun. They are:

- (1) Increased lethality
- (2) Increased range
- (3) Shorter time of flight and reduced "droop"
- (4) Reduced logistics costs

Research on these guns is currently occurring at WVA's partner facility, Benet Labs, in addition to a similar and more ambitious program at the ARDEC at Picatinny Arsenal, New Jersey. ( There is work being conducted on related programs such as the Electromagnetic Coilgun, and the Electro-chemical Thermal Gun, but our discussion will be restricted to the Electromagnetic Railgun. ) ARDEC's efforts are centering on applications for the Army and USMC, but include uses for tanks, air/theater missile defense systems, infantry fighting vehicles, and armored amphibious assault vehicles.

Regardless of the application or use, the ability to effectively acquire a significant power source for the EMG remains the overriding concern. Today's tank main guns may propel a 7 kilogram projectile at the rate of 1.7 kilometer/second and require a chemical source of 10 megajoules for the

effort. In order to defeat a potential armored or fortified threat of the future, combat developers and wargamers believe that much greater energy on target will be needed. Current electrical sources do not yet routinely exceed the current chemical gun velocity. The goal for an EMG would be the same size projectile at least 2.5 km/sec, but would require a 20 megajoule source, the size of a small house. An acceptable goal for a smaller caliber gun (90mm) and only drawing 9 mj has been delivered to ARDEC for further research.

The Center for Electromechanics at The University of Texas at Austin has developed this barrel in conjunction with ARDEC. Although superficially resembling a conventional steel barrel, that's where the similarity ends. Embedded within the external composite barrel is a series of ceramics, metals, and composite sleeves on a hydraulic rim which surround the copper electric armatures. Although laboratory testing has just begun, there is much promise in this type of EMG barrel. Many issues of applied technology are yet to be resolved, but effort and dollars are being placed against this program.

Developmental testing will be conducted in the summer of 1994 on this gun. A smaller caliber design in the 20-40mm range and drawing significantly less pulse power is scheduled for test in summer 1995. Because of the smaller caliber, the pulse power source may by then be able to be integral with the military vehicle itself. The USMC is supporting this effort, and sees it as the main gun system on its armored amphibious assault vehicle ( ARAAV ).

The future of this program seems fairly robust with money throughout the POM period. A large caliber demonstration/validation is not even planned until 2003-2005 when the advanced composite barrel ( ACB ) or

other technology will have matured and suitable 20mj power sources can be carried on-board the ground vehicle itself. Although far off in to the future with production and fielding not occurring until 2010 at the earliest, this is an application in keeping with WVA's core capability for which it would do well to begin to position itself. This is especially true in light of the possible massive infrastructure costs which could be required over the next fifteen years for such a program. <sup>29</sup>

## CONCLUSIONS

We began this snapshot with the initial thrust being towards developing WVA's future by capitalizing on ceramics and composites applied technology. A second area of inquiry was into what WVA's future should be in the industrial base irrespective of ceramics and composites. In an environment of shrinking defense dollars, decreasing military forces to support, and retaining its core competency as cannon-maker, this role in the industrial base remains pre-eminent.

Although a number of fascinating options are available to WVA in ceramics and composites, the emphasis must be placed upon technology rather than on industrial applications. Sputtering coatings and the like provide a great opportunity to allow greater wear life for large caliber thick-walled cannon in the future, but the vagueness of the specific application and the year of its introduction must encourage caution. The fact that the services have no stated requirement for significantly extending the tube wear life is key to this caution. Continuing close relationships with Benet Labs and others will allow WVA to dovetail its manufacturing capability with that of the R & D community and preclude a further or untimely capital investment in this application.

The DOD in general, and WVA in particular, must be appreciative to the Congress for its support in defense conversion. Both from a budgetary and from a legislative standpoint, WVA has done well by Congress and its local representatives in ensuring laws favor WVA's entry and continuing presence into manufacture of civilian products, and the budget to support that effort. This effort, however, so far seems to have been for naught. As

favorable as these programs may appear for WVA and other defense manufacturers, what we have is a newcomer trying to enter a mature product market in which there are already numerous providers and few consumers. Yes, WVA does have a great capability to provide products on the periphery of its core competency to civilian markets, but so do others. Massive recapitalization on the scale of Project REARM is not the answer; improved allocation rules for costing overhead might well be. The current costing and price structure, dictated by OSD to include the amortization of all the investment of Project REARM and the FCIM into its overhead, remains prohibitive. These DOD practices block the efficient and effective use of this resource, skew the true costs and benefits of WVA in a competitive environment, and cloud the timely downsizing of the DOD structure. Innovative costing, such as ABC, could provide equity and relief. With what may be the finest, flexible, computerized machine shop in the world to include its computerized design and stereo lithography capability, WVA stands as a national resource, too important to our nation's future to be allowed to deteriorate. WVA's ability and responsiveness in developing the "bunker-buster" for the Persian Gulf War is a magnificent example of this.

To make use of the minor and occasional advantages afforded by Congressional legislation in the dual-use and conversion arena will provide some funding, some jobs and job security, and is the politically astute azimuth. However, defense dual-use and conversion projects should be seen as ancillary and politically expedient, hardly a significant prospect for the future.

International Cooperation, also known as security assistance or foreign military sales ( FMS ) is a sometimes overlooked avenue for growth. Because of decreasing military budgets worldwide, apparent profusion of

potential providers chasing after the same consumers, and legal complexities which turn the most simple buy-sell agreement into a political football, FMS is often summarily ignored. This should not be so in the case of WVA. Neither AMC nor USASAC leadership and their legal staffs see any procedural or legal problems with WVA's cannon tubes being promulgated throughout the world. Although there are arms merchants such as and the United Kingdom's Royal Ordnance and France's GIAT doing business with the countries of the former Warsaw Pact, those nations are also coming to us for applied technology to standardize and upgrade their armored fleets. Through the State Department's Partnership for Peace program, a logical and developing avenue is already provided for travel. WVA's mature cannon technology is universally recognized as the best available. Retrograding the thousands of armored and artillery pieces of the new Partners in Peace through U.S. GOGO and GOCO re-manufacturing facilities for upgrade would do great things for military interoperability, but may well be impractical. Rather, upgrading these pieces of equipment in the former Warsaw Pact countries with our technology, and our workers as trainers is an inviting alternative. To not take advantage of promoting WVA's core capability will allow our industrial base to degrade that much more quickly to the benefit of other Allies with similar heavy cannon capability, and subsequently diminish our role in the post-Cold War World.

The handwriting is clearly on the wall. Foregoing a massive program such as Partners for Peace FMS, the industrial base will significantly diminish with WVA being part of that diminution. The Report on the Bottom-Up Review, Dr. Perry's comments, and the budget realities through the end of the decade clearly point to a more austere and lean base. There is no reason to believe that there will be protected facilities, but there will be

protected core capabilities. In Les Aspin's Annual Report to the President and the Congress January 1994, he writes of only two protected core capabilities, nuclear propulsion for surface ships and submarines. WVA, the acknowledged thick-walled, large caliber leader in the US, if not the world, should do everything possible to reinforce and promote that role and capability. This is one area in which Congressional legislation and assistance would be vital to WVA.

The two MRC strategy of the BUR suggests incorrectly that there will *not be a need* to "fire up" the base in future conflict. The Gulf War provided us ample proof to subscribe to the probability that such a "firing up" would not be necessary. However, *the calculus has changed significantly* from a standpoint of ready and available forces, depth of equipment and other supplies, and even more restricted strategic lift resources. All this must be posited against a backdrop of increased global military commitments, and probability that a future adversary will be less generous in allowing us the opportunity to deploy and build up forces with relative impunity. Such a scenario increases risk considerably, with a commensurate increase in personnel casualties and equipment losses.

In the aftermath of a conflict, a great need to replenish our armaments as well as those of our allies will arise. WVA will be a logical choice for much of this replenishment. How is WVA to do it? By developing a multi-tiered surge plan which, in the absence of other work, allows the arsenal to draw down progressively smaller while retaining core capability to replenish products from the warming base when called upon. The ability to start low-rate manufacture or re-manufacture production on short notice is in the spirit of the new industrial base strategy, and fits a role that WVA can achieve. Such a surge plan will manifest WVA as a team player in the

drawdown of the US industrial base, will protect the core competency, and allow for rapid resurgence of cannon production when called for.

In sum, the hope of the future for WVA is where the intersection of WVA's capability and the nation's potential requirements lie. The drawdown and development of WVA and its surge plan is one aspect. The other aspect lies where the stated military requirements and evolving credible cannon technologies intersect: electro-magnetic guns. As discussed earlier, much work is being done in the area of electric guns even though the application of this technology is far into the future. At the earliest, field demonstrations of the EMG will not even occur until the summer of 1994. Into the 21st Century will be the first working prototypes which might be fielded, with actual production not occurring earlier than 2010. Although a number of years out, this period of time will allow WVA to develop and invest a capitalization plan for the production of EMGs. Close cooperation with the R & D community could cause WVA to be in the right position to produce the new wave of cannon for the future.

## RECOMMENDATIONS

WVA is doing much and can continue to do much to help itself into the 21st Century. It can do this by doing what is necessary for America's defense at the same time helping itself survive as an important player in defense. The question now is not so much what it might do, but when. A time-phased plan is what will work for them.

### Now

The relationships developed and nurtured with Congress on Defense Conversion and dual-use need to be fostered. They have provided some jobs and continue to do so; there is no reason why WVA should not appear as a team player. Continue to use the legislation and funds in the spirit and to the letter in which they are provided and demonstrate their limited value, as appropriate. This should be fostered simultaneously while attempting to secure Congressional assistance for WVA's national core competency for large caliber, thick-walled gun tubes to be recognized.

Partnership for Peace FMS is the best, short-term, possible provider of business for WVA. Vigorous pursuit of this prospect with IOC and USASAC is necessary for WVA to cash in on this burgeoning field.

Although not necessarily the " silver bullet " technology that some had hoped for, the application of ceramics and composites will continue to play an important role in defense technology. Sputtering coatings and other uses do hold promise despite the lack of a current requirement document from the Services. The ceramics and composites intertwinings used on the ACB (Advance Composite Barrel ), do provide, however, a bright light into the

future even though we are years away from a production-level of application of the ACB. We are years away but this approach is one which the services show sincere interest in and is one for which the services are willing to post a requirement. Continuing close cooperation with the military and university laboratories should provide WVA the opportunity to schedule infrastructure funding today for eventual production of EMG.

WVA is already re-structuring and is working towards meeting challenges of a smaller, more responsive facility. With an eye towards maintaining its core capability, while simultaneously emphasizing its unique REARM and FCIM talents, WVA must develop its downsizing and surge plan to multi-tier itself for differing levels of low and high rate production. To what level and how quickly it should achieve these levels is dependent not so much upon the exigencies of the Defense Drawdown, but upon the rapidity with which it embraces FMS.

### **Mid-Term**

Expansion and continuation of three programs should provide WVA its future:

- (1) FMS
- (2) EMG
- (3) Unique and Vital Manufacturing Capability

None of these provides the one answer for the future. However, sales of mature technology which could have many takers, while continuing preparation towards the electro-magnetic gun technology for which there is and should continue to be a requirement are proper thrusts. Development and marketing of WVA's unique capability, and rightsizing of the surge industrial base are good areas of emphasis for both WVA and the nation.

## **21st Century and Beyond**

Even into the 21st Century and beyond, there will be a need to fight with Armor protection. The protection and shape may be different, but there will be such a need. Although we appear to be in an interregnum, there will certainly be wars in the future in which the U.S. will need to have a major global fighting force.

If the mid-term vision is correct, we can only conclude that as FMS continues, and WVA's unique and vital capabilities continue to be recognized, EMG will come into its own as WVA meets yet another challenge to its capabilities. Since its founding, Watervliet Arsenal has always prospered when its unique and excellent capabilities intersected with the needs of the Nation and its Armed Forces. Its future will be no different.

## ENDNOTES

1. LTCs Robert F. Dees and Bristol W. Williams, "Watervliet Arsenal: Snapshot of Industrial Base Change", ICAF 1992
2. Watervliet Arsenal, Watervliet Arsenal Strategic Level Enterprise Plan, 24 November 1992
3. ICAF, ICAF Research and Writing Handbook, Suggested Research Topic #F12, Strategic Planning Support to Watervliet Arsenal, AY 1993-1994, p. 46
4. Dave Callahan, "Scope of Work", Interview, Watervliet Arsenal, 1 October 1993
5. Watervliet Arsenal, History of Watervliet Arsenal, 1813 to Modernization, 1982, p.2
6. Ibid., p.74
7. Louisville Site, Crane Division, NSWC, "Welcome Packet", July 1987
8. Dees and Williams, *ibid.*, p.32
9. Joe F. Jones, "Primer on Composites and Ceramics", JF Jones Group, December 1, 1993, pp. 4-6
10. *Ibid.*, pp. 8-12
11. David Berteau, Chairman, Defense Conversion Commission, "Presentation", 26 October 1993
12. Base Realignment and Closure Commission (BRAC) 1991, Findings and Recommendations, various
13. Les Aspin, Secretary of Defense, Report on the Bottom-Up Review, October 1993, p.97
14. *Ibid.*, p. 105
15. OTA (Office of Technology Assessment), US Congress, Future of Defense Industrial Base, 1988, various

16. Dick Cheney, Secretary of Defense, Annual Report to the President and the Congress, January 1993, p. 57
17. Les Aspin, Secretary of Defense, Defense Planning Guidance, FY 1995-1999, p. 42
18. Dr. William Perry, Deputy Secretary of Defense, "Government Executive" Interview, October 1993, pp. 74-79
19. Annual Report, *ibid.*, p.82
20. US Congress, "Conference Agreement, Title VIII, Acquisition Policy, Acquisition, Management, and Related Matters", October 21, 1990
21. US Congress, USC 3710a, " Cooperative Research and Development Agreements "
22. US Congress, 10 USC 4552, " The Stratton Amendment "
23. MG (RET) Paul Greenberg, CG, AMCCOM/IOC, " Interview", 1 December 1993
24. *Ibid.*
25. Dr. George Capsimanlis, " Sputtering and Ceramic Components", Interview, Benet Labs, 1 October 1993
26. Troiano and Spencer, MSSRS., " Satisficing Wear and Strength in Ceramics", Report and Interview, Benet Labs, 1 October 1993
27. Picatinny Arsenal, "Visit", 4 March 1994
28. Paul Donovan, Deputy, USASAC, "Interview", 2 December 1993
29. MAJ Cary Linnerud, Electric Armaments Overview, Briefing, Picatinny Arsenal, 4 March 1994